INTELLIGENT ELECTRONIC DEVICE HAVING AN XML-BASED GRAPHICAL INTERFACE

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ABSTRACT

An intelligent electronic device (IED) having an interface for displaying data sensed and generated by the intelligent electronic device and other IEDs on a network is provided. The intelligent electronic device includes at least one sensor coupled to the electric circuit configured for measuring at least one power parameter of the electrical circuit and generating at least one analog signal indicative of the at least one power parameter; at least one digital to analog converter coupled to the at least one sensor configured for receiving the at least one analog signal and converting the at least one analog signal to at least one digital signal; a processor configured for receiving the at least one digital signal and generating energy data; a communication device configured for accessing at least one second intelligent electronic device; and an interface configured for displaying data generated by the at least one second intelligent electronic device.

FROM ELECTRICAL DISTRIBUTION SYSTEM

SENSORS

POWER SUPPLY

A/D CONVERTERS

DSP

CPU

MEMORY

DISPLAY

COMMUNICATION DEVICE

AUDIBLE OUTPUT

XML DATA FILE

XML SOURCE FILE

SELECTED MAP FILES

ALIGNMENT FILES

FILE TYPES

TO LOAD

LOAD FILES
FIG. 1

FROM ELECTRICAL DISTRIBUTION SYSTEM

SENSORS → A/D CONVERTERS → DSP

POWER SUPPLY

CPU

MEMORY

SCREEN LAYOUT XML FILES
MODBUS/XML SETUP FILES
XML DATA FILE
SUPPORT FILES

COMMUNICATION DEVICE

DISPLAY

AUDIBLE OUTPUT

TO LOAD
SENSE POWER SIGNALS AND GENERATE POWER DATA

TAG SENSED AND GENERATED DATA WITH XML TAGS

RECEIVE SCREEN SELECTION

RETRIEVE SCREEN LAYOUT XML FILE

RETRIEVE XML TAGGED DATA AND APPLY TO SCREEN LAYOUT

DISPLAY DATA

FIG. 2
FIG. 3A
FIG. 3B
FIG. 3C
<xml version="1.0" encoding="UTF-8"?>
<!-- Electro Industries/GaugeTech embedded network server default polling profile -->
- <EIG_POLL_DATA>
  - <EIG_SYSTEM>
    <item DATA_POLL_DELAY="500" ALARM_POLL_DELAY="1000"
      SYSTEM_COMM_TIMEOUT="500" ALARM_CONTACT_PHONE=""
      ALARM_CONTACT_PERSON="Administrator"/>
    <item EMAIL_1="" FORMAT_1="long" EMAIL_2="" FORMAT_2="long"
      EMAIL_3="" FORMAT_3="long" EMAIL_4="" FORMAT_4="short"
      EMAIL_5="" FORMAT_5="short" EMAIL_6="" FORMAT_6="short"
      EMAIL_7="" FORMAT_7="short" EMAIL_8="" FORMAT_8="short"/>
  </EIG_SYSTEM>
  - <DEVICE_1>
    <item DEV_TYPE="[~DEVICE_TYPE_LABEL]" DEV_PROTOCOL="Modbus RTU"
      DEV_NAME="[~DEVICE_LABEL]" DEV_ADDRESS="1" DEV_IP=""
      DEV_MAX_PACKET_LEN="127" DEV_DATA_FORMAT="0.00"
      DEV_POLL_ALARM="yes" DEV_ALARM_OPTIONS="1+2+3+4+5+7+9"
      DEV_ALARM_DELAY="0" DEV_COMM_TIMEOUT="500"
      DEV_PARENT="1"/>
  </DEVICE_1>
</EIG_POLL_DATA>
</xml>

FIG. 4A
<item D_UID="1_26" D_LABEL="Min Vab" D_ADDR="419"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="3"
D_VALUEMODE="Primary" />
<item D_UID="1_27" D_LABEL="Min Vbc" D_ADDR="421"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="3"
D_VALUEMODE="Primary" />
<item D_UID="1_28" D_LABEL="Min Vca" D_ADDR="423"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="3"
D_VALUEMODE="Primary" />
<item D_UID="1_29" D_LABEL="Min Freq." D_ADDR="465"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="0"
D_VALUEMODE="Primary" />
<item D_UID="1_30" D_LABEL="Min Ia" D_ADDR="409"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="1"
D_VALUEMODE="Primary" />
<item D_UID="1_31" D_LABEL="Min Ib" D_ADDR="411"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="1"
D_VALUEMODE="Primary" />
<item D_UID="1_32" D_LABEL="Min Ic" D_ADDR="413"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="1"
D_VALUEMODE="Primary" />
<item D_UID="1_33" D_LABEL="Min Inc" D_ADDR="417"
D_LENGTH="2" D_TYPE="7" D_USE_SPECIAL="2"
D_VALUEMODE="Primary" />
<item D_UID="1_34" D_LABEL="Last Max Reset" D_ADDR="6019"
D_LENGTH="4" D_TYPE="3" D_VALUEMODE="Primary" />
<item D_UID="1_35" D_LABEL="Device Date/Time" D_ADDR="85"
D_LENGTH="4" D_TYPE="3" D_VALUEMODE="Primary" />
<item D_UID="1_36" D_LABEL="Meter Designation"
D_ADDR="45969" D_LENGTH="8" D_TYPE="1"
D_VALUEMODE="Primary" />
</DEV_DATA>
</DEVICE 1>
</EIG_POLL_DATA>

FIG. 4C
FIG. 5
FIG. 7
BACKGROUND OF THE INVENTION

1. Field of the Invention

The present disclosure relates generally to intelligent electronic devices for electrical power systems, and more particularly, to an intelligent electronic device having an XML-based graphical interface for displaying data sensed and generated by the intelligent electronic device.

2. Description of the Related Art

Electric utility companies ("utilities") track electric usage by customers using power meters. These meters track the amount of power consumed at a particular location. These locations range from power substations, to commercial businesses, to residential homes. The electric utility companies use information obtained from the power meter to charge its customers for their power consumption, i.e. revenue metering.

A popular type of power meter is the socket-type power meter, i.e., S-base or Type S meter. As its name implies, the meter itself plugs into a socket for easy installation, removal and replacement. Other meter installations include panel mounted, switchboard mounted, and circuit breaker mounted. Typically the power meter connects between utility power lines supplying electricity and a usage point, namely a residence or commercial place of business.

A power meter may also be placed at a point within the utility's power grid to monitor power flowing through that point for distribution, power loss, or capacity monitoring, e.g., a substation. These power and energy meters are installed in substations to provide a visual display of real-time data and to alarm when problems occur. These problems include limit alarms, breaker control, outages and many other types of events. Conventionally, the visual display includes numerical information and/or an alarm indication, e.g., a LED, LCD, etc., on the face of the meter. To determine the specific type and/or cause of the alarm, a user may have to scroll through numerous lines of information, inspect the actual piece of equipment relating to the alarm or review the alarm information at a headend of a SCADA (supervisory control and data acquisition) system which may be in a different location from the meter. All of these scenarios will delay rectifying the problem and may increase downtime of a consumer receiving the power. Once the problem is identified, the user will have to retrieve correction procedures and/or equipment manuals to rectify the problem causing further delays.

Furthermore, conventional power meters only display information or indicate alarms pertaining to the individual power meter having the display. Typically, a substation includes numerous power meters at various locations making it difficult to get readings form each of the power meters with similar time parameters. To date, the only way to get an idea of system reliability and telemetry at a substation is to install a dedicated personal computer running a SCADA application. However, SCADA systems are costly and personal computers are susceptible to failure in substation environments.

SUMMARY OF THE INVENTION

An intelligent electronic device (IED), e.g., an electrical power meter, having an XML-based graphical interface for displaying data sensed and generated by the intelligent electronic device is provided. The display of the IED of the present disclosure uses XML as its backbone allowing the display to read data out of an XML file and then display the data on a screen particular to what the customer pre-programs. Additionally, since the display uses XML data from a file, the user will be able to select files over a network, e.g., the Internet, grabbing XML data and formatting information from other meters making each meter a gateway to another meter on the system.

According to one aspect of the present disclosure, an intelligent electronic device (IED) for monitoring power usage of an electrical circuit is provided. The IED includes at least one sensor coupled to the electric circuit configured for measuring at least one power parameter of the electrical circuit and generating at least one analog signal indicative of the at least one power parameter.

At least one digital to analog converter coupled to the at least one sensor configured for receiving the at least one analog signal and converting the at least one analog signal to at least one digital signal; a processor configured for receiving the at least one digital signal and generating energy data; a communication device configured for accessing at least one second intelligent electronic device; and an interface configured for displaying data generated by the at least one second intelligent electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other aspects, features, and advantages of the present disclosure will become more apparent in light of the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagram of an intelligent electronic device in accordance with an embodiment of the present disclosure;

FIG. 2 is a flow chart illustrating a method for generating data to be displayed on an intelligent electronic device in accordance with the present disclosure;

FIGS. 3A-3D illustrates an exemplary screen configuration XML file in accordance with an embodiment of the present disclosure;

FIGS. 4A-4C illustrates an exemplary poll profile XML file in accordance with an embodiment of the present disclosure;

FIG. 5 illustrates an exemplary XML data file in accordance with an embodiment of the present disclosure;

FIGS. 6A-6P illustrate several screen shots produced on a display of an intelligent electronic device in accordance with the present disclosure; and
FIG. 7 is a diagram of a system of intelligent electronic devices according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

Preferred embodiments of the present disclosure will be described hereinbelow with reference to the accompanying drawings. In the following description, well-known functions or constructions are not described in detail to avoid obscuring the present disclosure in unnecessary detail.


An intelligent electronic device (IED) 10 for monitoring and determining an amount of electrical power usage by a consumer and for providing audible and visual indications to a user is illustrated in FIG. 1. Generally, the IED 10 includes sensors 12, a plurality of analog-to-digital (A/D) converters 14, a processing system including a central processing unit (CPU) 18 and/or a digital signal processor (DSP) 16 and memory 26, e.g., RAM, flash memory, etc. The sensors 12 will sense electrical parameters, e.g., voltage and current, of the incoming lines from an electrical power distribution system. Preferably, the sensors will include current transformers and potential transformers, wherein one current transformer and one voltage transformer will be coupled to each phase of the incoming power lines. A primary winding of each transformer will be coupled to the incoming power lines and a secondary winding of each transformer will output a voltage representative of the sensed voltage and current. The output of each transformer will be coupled to the A/D converters 14 configured to convert the analog output voltage from the transformer to a digital signal that can be processed by the CPU 18 or DSP 16.

The CPU 18 is configured for receiving the digital signals from the A/D converters 14 to perform the necessary calculations to determine the power usage and controlling the overall operations of the IED 10. In another embodiment, the DSP 16 will receive the digital signals from the A/D converters 14 and perform the necessary calculations to determine the power usage to free the resources of the CPU 18. It is to be appreciated that in certain embodiments the CPU 18 may perform all the functions performed by the CPU 18 and DSP 16, and therefore, in these embodiments the DSP 16 will not be utilized.

A power supply 20 is also provided for providing power to each component of the IED 10. In one embodiment, the power supply 20 is a transformer with its primary windings coupled to the incoming power distribution lines and having an appropriate number of windings to provide a nominal voltage, e.g., 5 VDC, at its secondary windings. In other embodiments, power is supplied from an independent
source to the power supply 20, e.g., from a different electrical circuit, a uninterruptible power supply (UPS), etc.

[0026] The IED 10 of the present disclosure will include a multimedia user interface for interacting with a user and for communicating events, alarms and instructions to the user. The user interface will include a display 22 for providing visual indications to the user. The display 22 may include a touch screen, a liquid crystal display (LCD), a plurality of LED number segments, individual light bulbs or any combination of these. The display 22 may provide the information to the user in the form of alpha-numeric lines, computer-generated graphics, videos, animations, etc. The user interface will also include a speaker or audible output means 24 for audibly producing instructions, alarms, data, etc. The speaker 24 will be coupled to the CPU 18 via a digital-to-analog converter (D/A) for converting digital audio files stored in memory 26 to analog signals playable by the speaker 24. An exemplary interface is disclosed and described in commonly owned co-pending U.S. application Ser. No., entitled “POWER METER HAVING AUDIBLE AND VISUAL INTERFACE”, which claims priority to U.S. Provisional Patent Appl. No. 60/731,006, filed Oct. 28, 2005, the contents of which are hereby incorporated by reference in its entirety.

[0027] The IED 10 of the present disclosure will support various file types including but not limited to Microsoft Windows Media Video files (.wmv), Microsoft Photo Story files (asf), Microsoft Windows Media Audio files (.wma), MP3 audio files (.mp3), JPEG image files (.jpg, .jpeg, .jpe, .jfif), MPEG movie files (.mpg, .mpeg, .mpe, .m1v, .mp2v, .mpeg2), Microsoft Recorded TV Show files (.dvr-ms), Microsoft Windows Video files (.avi) and Microsoft Windows Audio files (.wav).

[0028] In addition to storing audio and/or video files, memory 26 will store the sensed and generated data for further processing and for retrieval when call upon to be displayed. The memory 26 includes internal storage memory, e.g., random access memory (RAM), or removable memory such as magnetic storage memory; optical storage memory, e.g., the various known types of CD and DVD media; solid-state storage memory, e.g., a CompactFlash card, a Memory Stick, SmartMedia card, MultiMediaCard (MMC), SD (Secure Digital) memory; or any other memory storage that exists currently or will exist in the future. By utilizing removable memory, an IED can be easily upgraded as needed.

[0029] The memory 26 will include a plurality of files for enabling the XML-based display of the present disclosure including but not limited to screen layout, e.g., configuration, XML files 28, Modbus/XML setup files 30, XML data files 32 and support files 33. The screen layout XML files 28 are configuration files that determined the screen layout of the display 22, e.g., variables to be displayed such as voltage and current, screen colors, font size of text, etc. It is to be appreciated that the screen layout XML files may be preloaded as default screen for the display. Additionally, the screen layout XML files may be created with a separate software package residing on a personal computer wherein the files may be downloaded from after created. Further, the IED 10 may include a configuration mode where screen layout can be generated and saved via the display 22. Each screen layout XML file will retrieve XML-tagged data as will be described below. An exemplary screen configuration file is illustrated in FIGS. 3A-3D.

[0030] The Modbus/XML setup files 30 will process sensed and/or generated data and will place XML tags on each piece of data. An exemplary setup file is illustrated in FIG. 4A-4C. This XML-tagged data will be stored in the XML data file 32. In one embodiment, the CPU 18 will interact with the Modbus/XML setup files 30 to tag data that was sense and/or generated in the particular IED. In another embodiment, the CPU 18 will receive data from another IED communication device 34 operating under a known protocol, e.g., Modbus, and will interact with the Modbus/XML setup files 30 to strip the Modbus wrapper off the incoming data and to place XML tags on each piece of data. As described above, each XML-tagged data will be stored in the XML data file 32. An exemplary XML data file is illustrated in FIG. 5.

[0031] The support files 33 include but are not limited to text, fonts, images, objects, sounds, etc. The support files 33 will be used by the XML configuration files 28 to create the look and feel of the screen being displayed to the user.

[0032] It is to be appreciated that although the embodiments disclosed herein employ XML (Extensible Markup Language) other programming languages may be employed. For example, a web server program may be stored in memory 26 and provide the data through any know web server interface format, e.g., HTML.

[0033] The IED 10 will include the communication device 34 for enabling communications between the IED 10 and other computing devices, e.g., a desktop computer, laptop computer, other IEDs, etc. The communication device 34 may be a modem, network interface card (NIC), wireless transceiver, etc. As described above, the IED 10 may be coupled to a personal computer over a network, e.g., a LAN, WAN, the Internet, serial networks such RS485, etc., via the communication device 34, where the personal computer will generate screen layout XML files to be downloaded to the IED 10.

[0034] It is to be understood that the present disclosure may be implemented in various forms of hardware, software, firmware, special purpose processors, or a combination thereof. The IED also includes an operating system and micro instruction code. The various processes and functions described herein may be part of the micro instruction code or part of an application program (or a combination thereof) which is executed via the operating system.

[0035] It is to be further understood that because some of the constituent system components and method steps depicted in the accompanying figures may be implemented in software, the actual connections between the system components (or the process steps) may differ depending upon the manner in which the present disclosure is programmed. Given the teachings of the present disclosure provided herein, one of ordinary skill in the related art will be able to contemplate these and similar implementations or configurations of the present disclosure.

[0036] Referring to FIG. 2, a method for displaying data of an IED will now be described. Initially, the IED 10 will sense voltage and current on at least one phase of an electrical distribution system (step 102). Once sensed, the DSP 16 and/or CPU 18 will perform various calculations to
generate data such as phasors, power consumption, etc. The CPU 18 will interact with the Modbus/xml setup files 30 stored in memory 26 to tag the sensed and generated data with XML tags (step 104). The XML-tagged data will then be stored in the XML data files 32.

[0037] From the display 22, a user will select a desired screen layout and the CPU 18 will receive the screen selection (step 106) and will retrieve the corresponding screen layout XML file (step 108). The CPU 18 will then retrieve the XML-tagged data from the XML data file 32 and apply the data to the screen layout (step 110). The display 22 will display the data according to the screen layout selected (step 112). Exemplary screen shots of the display are illustrated in FIGS. 6A-6P. FIG. 6 corresponds to the screen configuration file shown in FIGS. 3A-3D.

[0038] Referring to FIG. 7, a system of displaying data on an IED is illustrated. The system may include a plurality of IEDs 10, 204, 206, 210, 214, 216, 218 coupled to a network 202 through various communications links 203, for example, dial-up, hardwired, cable, DSL, satellite, cellular, PCS, wireless transmission (e.g., 802.11a/b/g), etc. and hardware such as router 208, personal computer 212 and modem 214. It is to be appreciated that the network 202 may be a local area network (LAN), wide area network (WAN), the Internet or any known network that couples a plurality of computers to enable various modes of communication via network messages. Furthermore, the network 202 will operate using the various known protocols such as Transmission Control Protocol/Internet Protocol (TCP/IP), File Transfer Protocol (FTP), Hypertext Transfer Protocol (HTTP), etc. and secure protocols such as Internet Protocol Security Protocol (IPSec), Point-to-Point Tunneling Protocol (PPTP), Secure Sockets Layer (SSL) Protocol, etc.

[0039] Each IED will be configured as described above so that each IED will employ identical XML tags. In this manner, an IED (e.g., IED 10) can connect to any other IED (e.g., IED 206), retrieve the XML-tagged data from the IED (e.g., IED 206) and display the data from the IED (e.g., IED 206) on the initiating IED (e.g., IED 10).

[0040] In one embodiment, at the initiating IED 10, a user will select the desired screen selection and then select the IED they want to view. To select the IED, the user will either enter the IP address of the IED or select the IED from a list of available IEDs that was preloaded. The preloaded list will include a list of all the IEDs or some identifier associated with the IED, e.g., boiler room, tenant 1, etc., in a particular system so a user can easily identify the IED they want to inquire about. Each IED or identifier in the list will have a corresponding IP address associated with it. In this manner, a user will not have to remember the IP address of each IED in a system but only its identifier. The initiating IED 10 will then load the screen configuration file and will poll the XML data file of the IED the user wants to view, e.g., IED 206. The data from IED 206 will then be transferred to IED 10 where a user can view the data of IED 206. Advantageously, a user can be standing in one substation and look at the metering data from a meter upstream or downstream to get a real time idea of the system is operating, not just a particular circuit.

[0041] In another embodiment, the network is self-configuring. The list associated the IED and/or identifier will be generated at any individual IED. The initiating IED will collect the information, e.g., IP addresses, from the other IEDs on the network and assemble the IED system list. The initiating IED will then transmit the system list to each IED on the network, and therefore, enabling each IED to access every other IED.

[0042] In a further embodiment, the initiating IED will retrieve the screen configuration XML file and the XML setup file from the IED the user wants to inquire about. In this embodiment, the initiating IED 10 will retrieve the configuration XML file and XML setup file from a desired IED, e.g., IED 206. Once retrieved and loaded, the IED 10 will retrieve data from the XML data file of IED 206 as described above. The data file may or may not be automatically refreshed by the initiating IED so that the initiating IED views the data from the IED the user wants to inquire about contemporaneously with the newly generated IED data the user wants to inquire about. In this manner, any IED in the system or on the network will act as a client interface, e.g., a browser, to replicate the interface displayed on any other IED in the system or on the network which would likewise be acting as a web server. This embodiment is advantageous when two IEDs are of different types. For example, if IED 10 is a revenue meter and IED 206 is a fault recorder, the screen configuration XML file and XML setup file of the revenue meter may be incompatible with the data generated and stored in the fault recorder.

[0043] In another embodiment, the initiating IED will retrieve the screen configuration XML file and the XML setup file from the IED the user wants to inquire about. In this embodiment, the initiating IED 10 will retrieve the configuration XML file and XML setup file from a desired IED, e.g., IED 206. Once retrieved and loaded, the IED 10 will retrieve data from the XML data file of IED 206 as described above. This will enable electric power utility users to view data on the initiating IED 10 via the local display including but not limited to a liquid crystal display, a light emitting diode display, or any other such display located on the IED or near the IED connected by communication cabling or wireless. This embodiment eliminates the need for substation personnel to use a desktop or laptop personal computer running a form of Microsoft Windows, Linux (such as Redhat brand Linux) or Apple branded OS to view system power quality information from the initiating IED 10 or the IED the user wants to inquire about located remotely in a substation located either, at the present location, upstream and/or downstream from the initiating IED, e.g., IED 204, IED 206, IED 210, etc.

[0044] Additionally, it will be understood that those skilled in the art would also use other protocol architectures to accomplish the IED screen configuration XML file, the XML setup file and other above mentioned files using an architecture that does not use XML, but uses any of the following but not limited to: binary files, .CSV (comma, separated value) files, ASCII files and/or encapsulated serial over Ethernet communication or other such files formats that utilize a similar function or purpose. Moreover, it will be understood that those skilled in the art would also use just configuration parameters such as or within a programmable setting with the initiating and the receiving IED the user wants to inquire about to send or receive data and/or configuration to and from the initiating and the IED the user wishes to inquire about. While the disclosure has been shown and described with reference to certain preferred
embodiments thereof, it will be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the disclosure.

What is claimed is:

1. An intelligent electronic device for monitoring power usage of an electrical circuit comprising:

   - at least one sensor coupled to the electric circuit configured for measuring at least one power parameter of the electrical circuit and generating at least one analog signal indicative of the at least one power parameter;

   - at least one digital to analog converter coupled to the at least one sensor configured for receiving the at least one analog signal and converting the at least one analog signal to at least one digital signal;

   - a processor configured for receiving the at least one digital signal and generating energy data;

   - a communication device configured for accessing at least one second intelligent electronic device; and

   - an interface configured for displaying data generated by the at least one second intelligent electronic device.

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